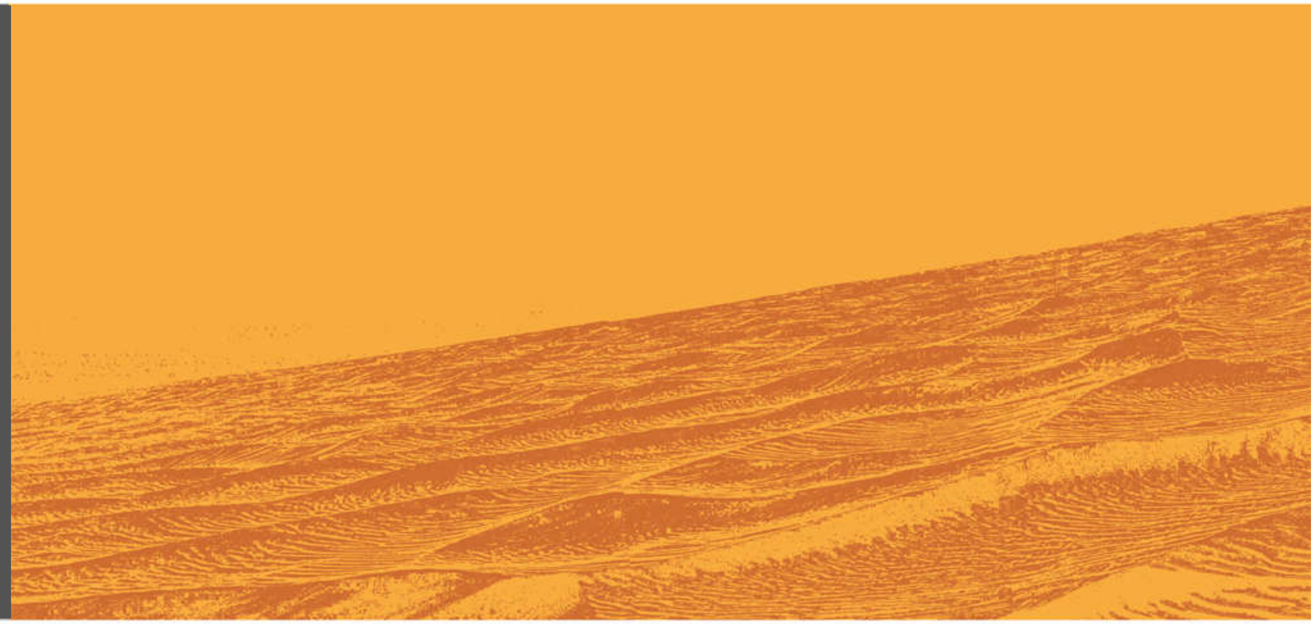


Mars 2018 Joint Rover Mission
Report from Joint Engineering Working Group (JEWG)
June 16, 2011

Topics

– Mission Requirements & Scenarios

– Rover Design Concepts & Key Considerations

– Plan Forward Details and Near-term Schedule

Current Status

- An interim Joint Science Working Group (iJSWG) has been chartered to help develop a set of candidate requirements and a reference mission scenario to help guide the engineering definition of joint rover design concepts worthy of further consideration
  - Key mission characteristics under discussion: Landing site access (altitude, latitude, morphology), Site characterization capabilities/instrumentation, In Situ Exobiology and Sample Caching capabilities and objectives, mission duration & expected mission return

- A Joint Engineering Working Group (JEWG) has been chartered to work with the iJSWG in developing cost-effective candidate design concepts (leveraging prior developments) potentially capable of meeting these requirements, as well as programmatic constraints, taking into consideration potential partnership modes.

- Work is being paced through the rest of this year by key programmatic milestones
  - More details later in presentation

Mission Requirements & Scenarios Summary

- The interim iJSWG has defined mission requirements that allow to pursue the 2018 joint science objectives. They are:

A. Landing Site Access: The rover shall land on, or be able to reach, a location possessing high exobiology interest for past life signatures, i.e. access an appropriate geological environment for the preservation of potential ancient biomarkers. The landing site shall include multiple targets enabling the *in-situ* characterization of surface and subsurface geology and exobiology, and the preparation of a cache of carefully selected, diverse samples from well documented environments for return to Earth.

B. In-situ investigations: The rover shall be able to conduct an integral set of measurements at multiple scales: beginning with a panoramic assessment of the geological environment, progressing to smaller-scale investigations on surface outcrops and soils, and culminating with the collection of well-selected surface and subsurface samples

   1. Geology: The rover shall be able to analyze the landing site's geology to provide sufficient information for the science team to document the geological context, to achieve the *in-situ* scientific objectives, and to select the materials to cache in support of returned sample science.
   2. Exobiology: The rover shall search for surface and subsurface organic molecules and physical and chemical biomarkers. The rover shall test the hypothesis that organics are better preserved at depth. The Rover shall have the ability to acquire samples from the subsurface, down to 2-m depth, and deliver these samples to its Analytical Laboratory Drawer (ALD) for processing and scientific analysis.

C. Sample acquisition and encapsulation: The rover shall have the ability to collect surface rock cores and granular material, such as regolith, and move them into a sample cache. The collected material shall be appropriately encapsulated and sealed for long-term storage on the surface of Mars, and for transport back to the Earth at a later date.

D. Surface mission concepts: The mission duration, operations approach, rover, ground and orbital capabilities shall allow pursuing the mission's *in-situ* and caching functions needed to achieve the mission science objectives.

Mission Requirements & Scenarios Summary

- iJSWG has adopted a terminology of communicating to JEWG **requirements** vs. **opportunities** during ongoing reformulation activities
  - Facilitates conversation about **mandatory** characteristics versus **highly desirable** characteristics warranting serious engineering and programmatic consideration

- Proposed Mission-level requirements from iJSWG to JEWG structured by area:

  - Area A: Landing site accessibility: Altitude, Latitude, Hazard/Slope Capabilities
    - **Area A Status:** General consensus on acceptability of MSL-class performance on Altitude & Hazard class
    - Latitude band of 25N to 15S acceptable as working baseline, although 25S or 30S (MSL capability) are desirable opportunities
    - iJSWG feels that adding some level of increased landing hazard tolerance/avoidance will open more sites than increasing latitude band, making this also a highly desirable opportunity [<u>Requires more detailed long-term engineering evaluation</u>]

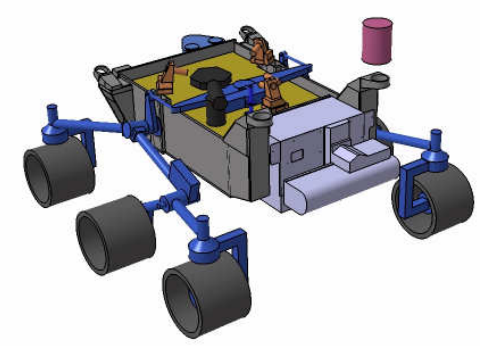
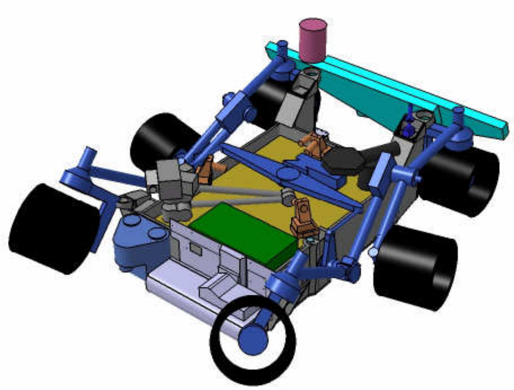
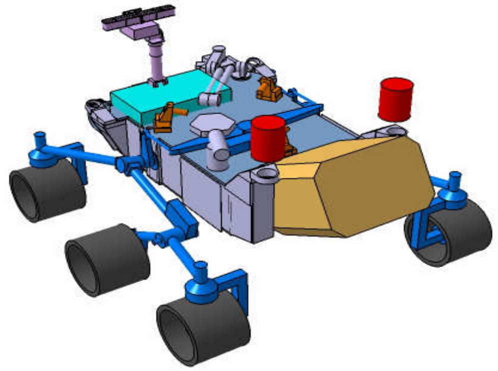
  - Area B: Capabilities/Instrumentation needed for landing site characterization prior to sampling activities
  - Area C: Capabilities/Instrumentation needed for *in situ* ExoBiology investigation of the site at and below the surface
  - Area D: Capabilities/Instrumentation needed for Sample Acquisition, Encapsulation, and Caching for sample return objectives
    - **Area B, C, D Status:** Payload/Instrument recommendations approached from perspective of "augmentations to" Pasteur payload elements previously selected for ExoMars mission. Existing mast-mounted visual imaging requires augmentation with mineralogy. Arm-mounted microscopic imaging, bulk elemental chemistry, and "resolved" mineralogy required, with organic detection from arm categorized as an opportunity. Ability to exchange samples from drill to encapsulation and caching system categorized as an opportunity more highly desired than ability to deliver cored rocks to *in situ* Analytical Laboratory [<u>Requires more detailed long-term engineering evaluation</u>]

  - Area E: Mission lifetime and consumables sizing considerations to meet an integrated mission scenario optimized to maximize mission return against objectives listed above (iterative process between JSWG & JEWG)
    - **Area E Status**: Assuming reasonable life-time cap of ~1 Mars Year (~670-700 sols), constructing credible scenario to achieve all prior objectives is proving rather challenging (esp. at sites requiring long initial traverses, "Go-To" sites, which may likely become a requirement rather than an opportunity)

Summary of Rover Concepts under Evaluation

- Three main candidate concepts identified, proposed by JEWG to be studied in more detail through the summer (illustrated on following slide)
  - Solar Rover with ALD & Drill on rear side, Robotic Arm (RA) & Cache on front side
    - Minimize ESA elements re-design (ALD height accommodated in Descent Stage "cavity" utilized by MSL RTG), contain ESA costs, design challenged to meet JSWG mission duration over recommended latitude band (chassis insulation and mitigation of dust deposition on arrays to be investigated - [Dust Mitigation - requires more detailed long-term engineering evaluation]), problematic sample exchange between subsurface drill and near surface coring systems
  - Solar Rover with ALD & Drill AND RA & Cache on front side
    - Implies ALD re-design, extent TBD, design challenged to meet JSWG mission duration over recommended latitude band (chassis insulation and mitigation of dust deposition on arrays to be investigated - [Dust Mitigation - requires more detailed long-term engineering evaluation]), easier sample exchange opportunity between subsurface drill and near surface coring systems
  - RTG Rover with ALD & Drill AND RA & Cache on front side
    - Implies ALD re-design, extent TBD, landing sites latitude range and mission operations duration achievable, easier sample exchange opportunity between subsurface drill and near surface coring/caching systems

Joint Rover concepts recommended for further study

	a) Solar power*	b) RTG power
Option # 1 ALD in Rear Cache in front		X
Option # 2 ALD in Front Cache in Front		

*deployed arrays omitted for clarity

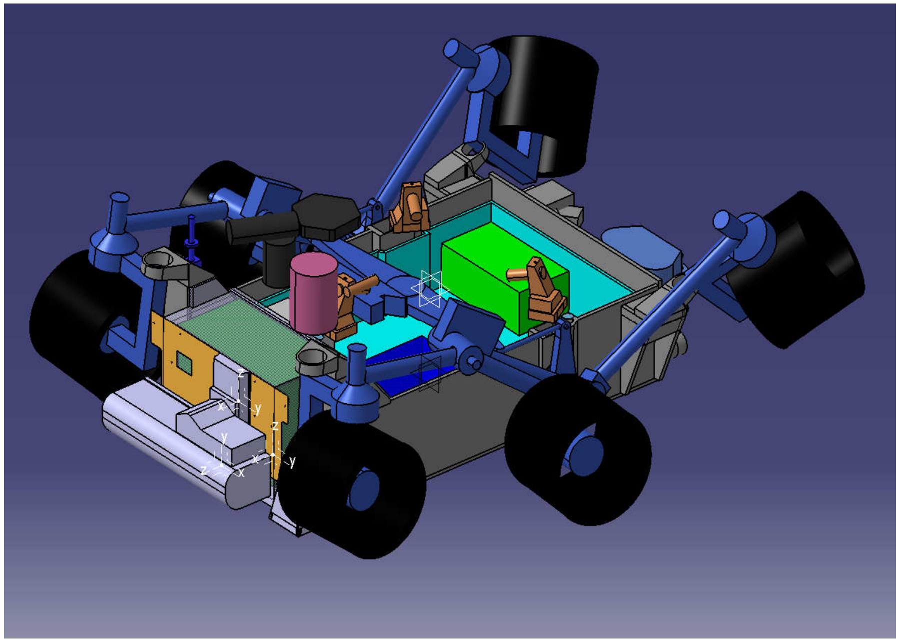
Contains Pre-decisional Material: For Planning and Discussion Only.
Subject to future Approval Processes from both NASA and ESA

Rover Design Concepts (1 of 2)

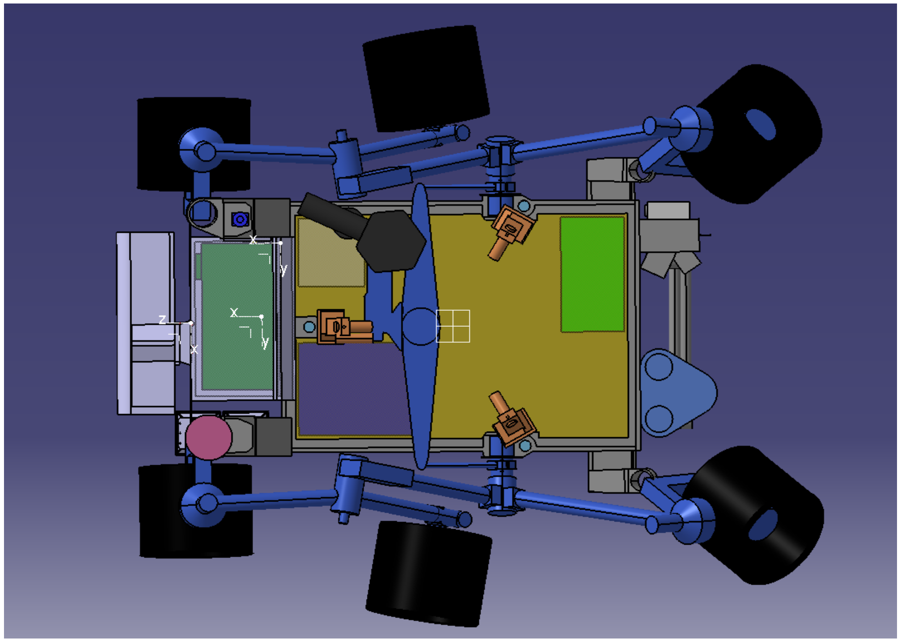
Option 1 : ALD, Drill on the rear side, RA and Cache on the front

- **Compatible with Solar Arrays configuration only**

  Implies Drill positioner re-design



(Rear Perspective - Arrays omitted for clarity)



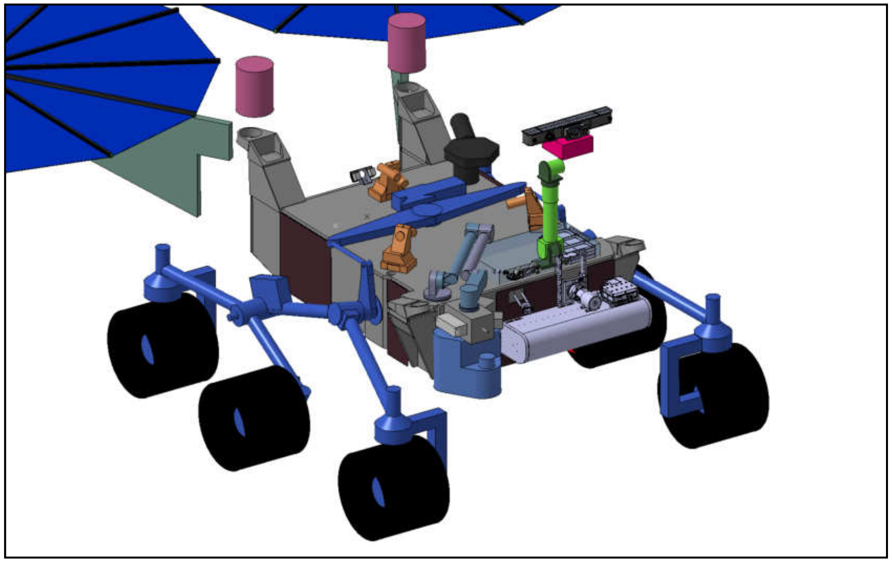
(Top View - Arrays omitted for clarity)

Rover Design Concepts (2 of 2)

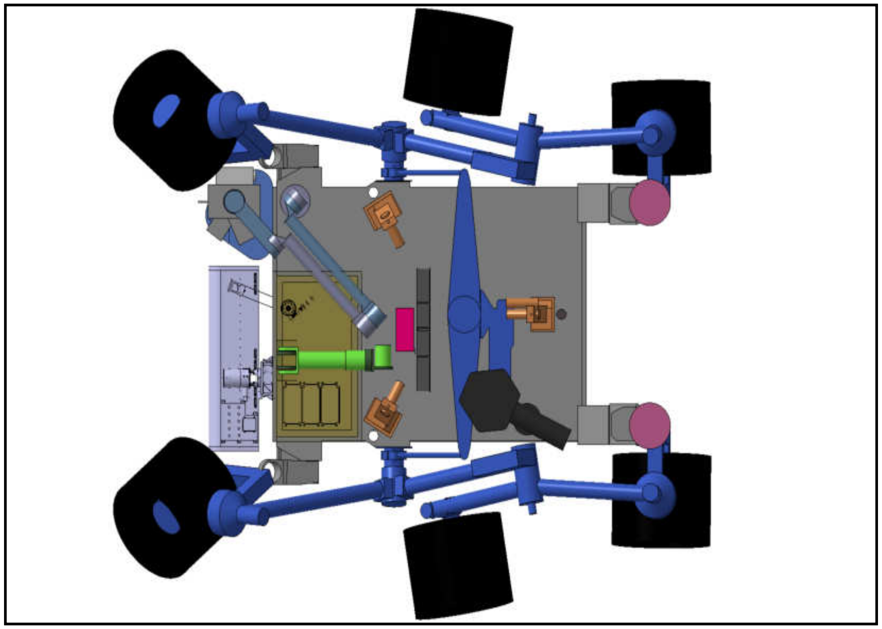
Option 2a (Solar), 2b (MMRTG): ALD, Drill , RA & Cache on the Rover Front

- **Compatible with both RTG and Solar Arrays configuration**

Implies ALD re-design + Drill positioner re-design



(Solar Configuration-expanded, shown. Configuration also compatible With RTG in rear volume)

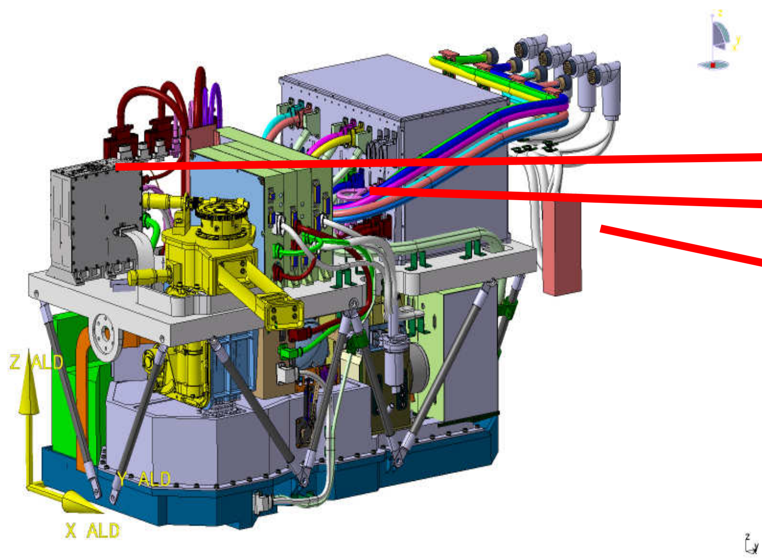


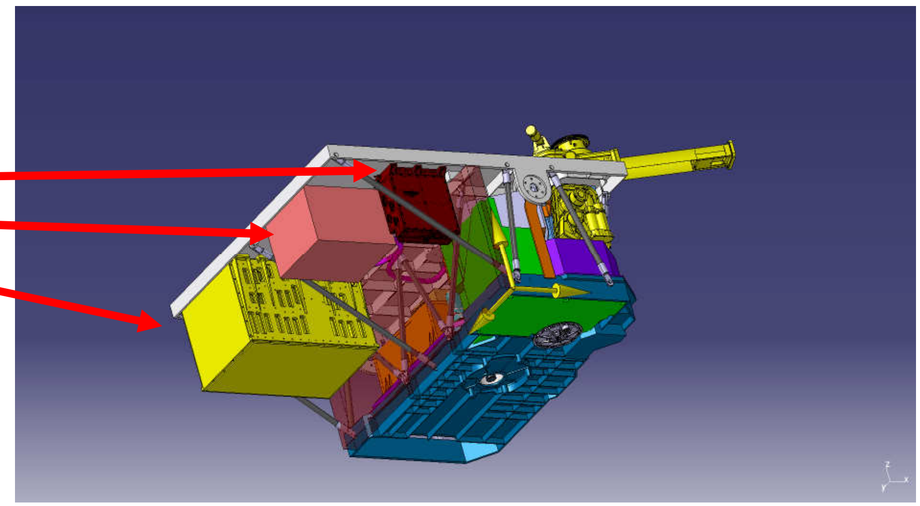
(Top View - Arrays omitted for clarity)

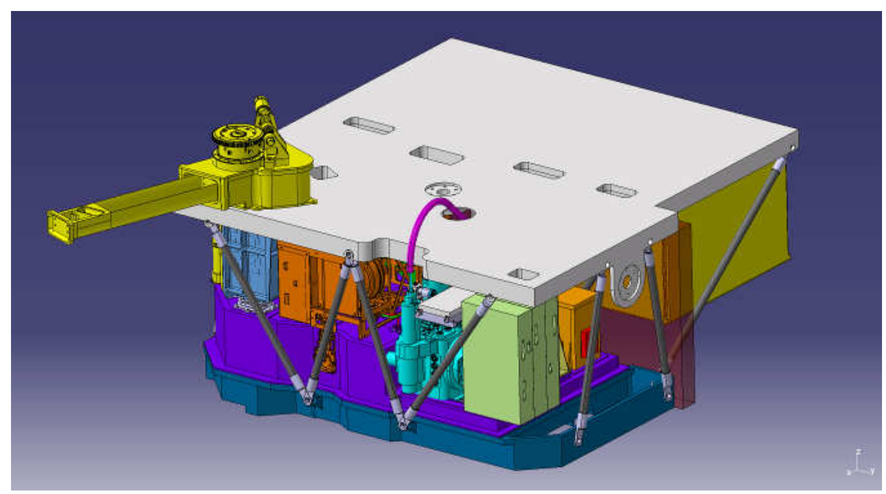
Analytical Laboratory Current Configuration, Options

EXM ALD current configuration.
Height Compatible with Option 1,
Rear mount (Entry Vehicle Volume occupied by MSL RTG)

Potential Modification Required for Option 2: Electronics units to be re-allocated (some or all), harness-optical fibers re-routing, impact on Structures and Thermal Control to be evaluated

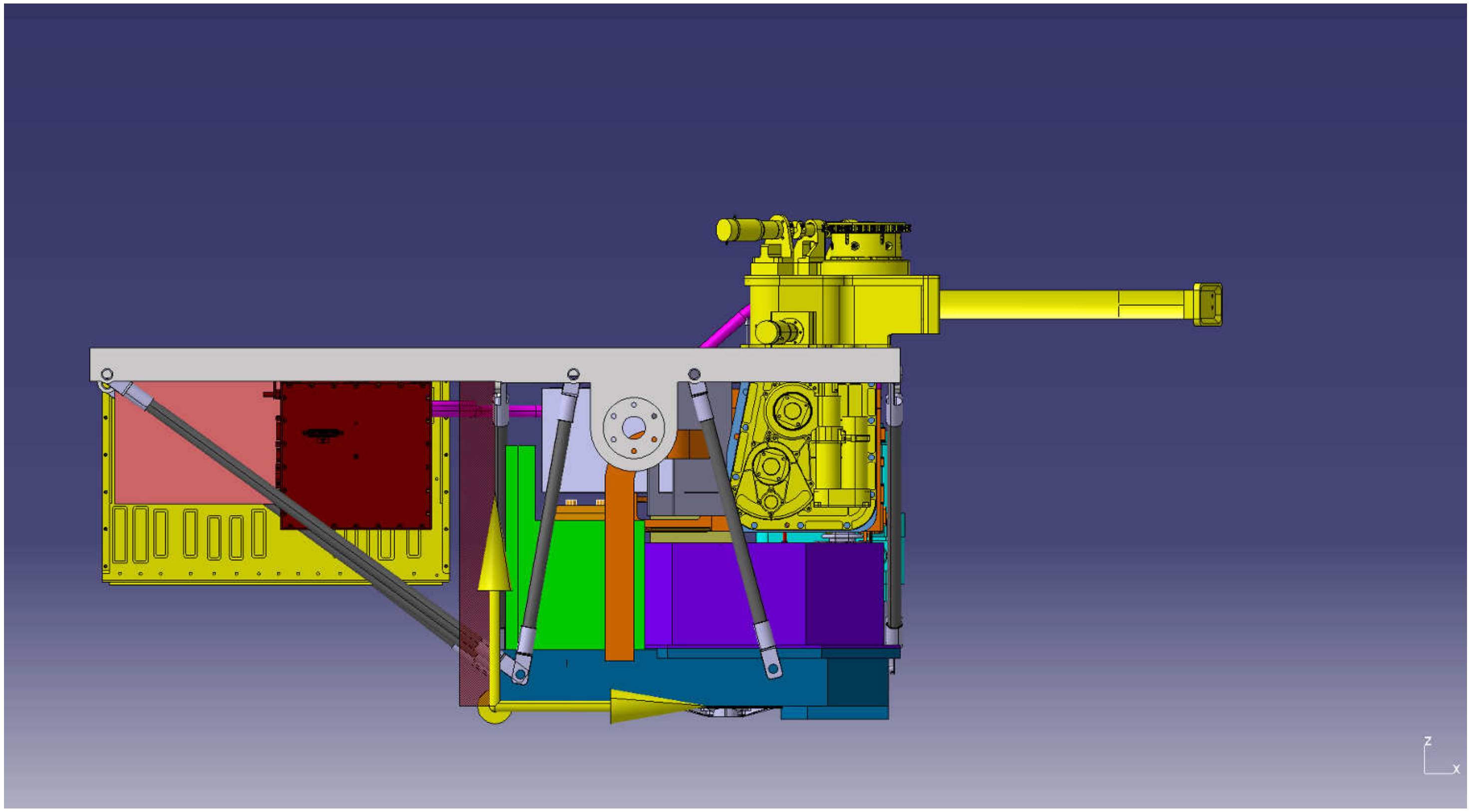




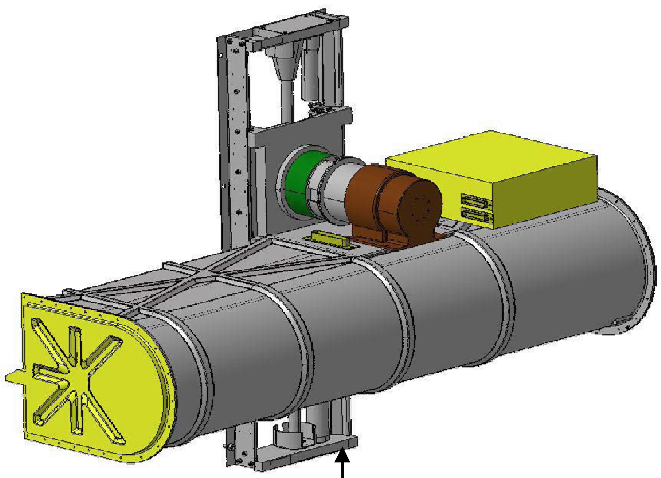


ALD Reconfiguration study

– Side view



Drill modification



Drill Positioner to be modified to reach the ground and maintain 2 m depth – One more DOF to be likely added

Plan Forward

- Series of Key Milestones and Reviews established to pace ongoing reformulation work:
  - Ongoing Requirements, Scenario & Technical Feasibility work (through ~July)
    - Mission Scenarios, Thermal/Power & Rover/Payload Configuration (esp. ALD) expected to be key drivers
  - Definition of mission concept adequate to support programmatic feasibility assessment by end of September
    - Implementation Planning and Cost estimate/proposal work to follow, Oct/Nov.
  - Study Completion Review in December
    - External review of adequacy/completeness of study, NASA/ESA Co-Chartered Technical/Programmatic/Cost Review of Study Results
  - Mission Concept Review and Formal Key Decision Point for Entry to Phase A in first quarter of 2012 calendar year
    - ~February/March for MCR, April/May for KDP-A
    - Goal for Announcement of Opportunity for additional payloads mid-year

Summary

- JEWG & iJSWG have initiated a process of defining a set of joint requirement candidates and joint mission scenarios for the joint rover
  - JSWG providing indications for each as to whether it is an "opportunity" (desire, subject to technical/programmatic evaluation) or "requirement" (likely to be mandatory under all assumptions)
  - Ongoing work on Mission Scenario harmonization/optimization continuing, in effort to improve estimates of expected mission return at 1 Mars year mark (687 days/668 sols).

- JEWG has identified 3 candidate rover concepts that warrant further development and evaluation against requirements and opportunities, as well as programmatic constraints and roles & responsibilities
  - Key near-term trades: Complexity of ALD repackaging to enable payload "co-location", Reasonable assumptions regarding rover chassis insulation required for solar powered concepts
  - Develop Driving requirements at subsystem in detail sufficient to allow implementation and cost estimates in the fall
  - Items likely requiring longer evaluation period: Exchange of samples between sample acquisition systems, feasibility of solar array dust mitigation, Possibility of Hazard Tolerance/Avoidance better than MSL capability (e.g. Terrain Relative Navigation)

- iJSWG & JEWG expect to continue to work together closely to converge requirements, scenarios and design in early summer, leading to implementation option concepts in late summer and into programmatic feasibility assessments in the fall
  - Consistent technical, programmatic, and cost baseline to be established by end of calendar year to support moving forward into formal project execution by start of calendar 2012

- The JMEB is working to reach common agreements based on interests and priorities of each Agency
  - Beginning detailed definition of the roles and responsibilities for the life cycle of the mission
  - Assigning contributions and areas of responsibilities based on heritage (MSL), previous developments (EXM) and technical feasibility